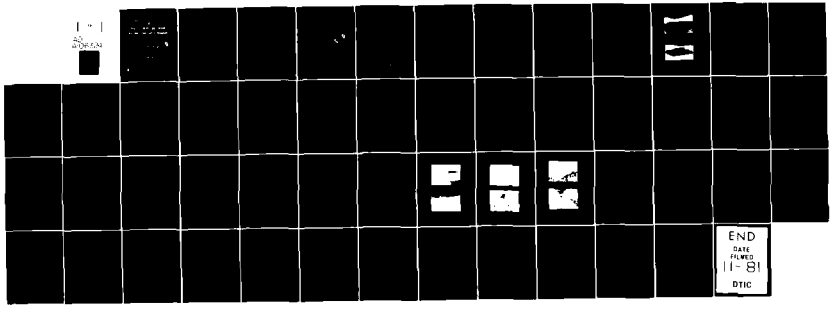
AD-A106 324 SCHNABEL ENGINEERING ASSOCIATES RICHMOND VA F/G 13/13
NATIONAL DAM SAFETY PROGRAM. LAKE FRONT ROYAL DAM (INVENTORY NU--ETC(U)
MAY 81 R E MARTIN, C S ANDERSON, J G STARR DACW65-81-D-0020

UNCLASSIFIED NL



END
DATE FILMED
11-81
DTIC

POTOMAC RIVER BASIN

Name Of Dam: LAKE FRONT ROYAL DAM

Location: WARREN COUNTY, VIRGINIA

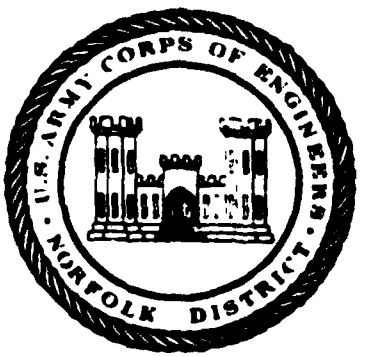
Inventory Number: VA. NO. 18705

C

LEVEL II

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

AD A106324



DTIC
ELECTE
OCT 2 9 1981
S D
H

PREPARED FOR

NORFOLK DISTRICT CORPS OF ENGINEERS
803 FRONT STREET
NORFOLK, VIRGINIA 23510

DTIC FILE COPY

"Original contains color plates: All DTIC reproductions will be in black and white"

DISTRIBUTION STATEMENT A
Approved for public release;
Distribution Unlimited

BY

SCHNABEL ENGINEERING ASSOCIATES, P.C./
J. K. TIMMONS AND ASSOCIATES, INC.

MAY 1981

81 10 27 312

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1 REPORT NUMBER: VA 18305	2 GOVT ACCESSION NO.: AD-A106 324
3 RECIPIENT'S CATALOG NUMBER:	
4 TITLE (and Subtitle): Phase I Inspection Report National Dam Safety Program Lake Front Royal Dam Warren County, VA	5 TYPE OF REPORT & PERIOD COVERED: Final
	6 PERFORMING ORG. REPORT NUMBER:
7 AUTHOR(s): Schnabel Engineering Associates, P. C. C. K. Timmons and Associates, Inc.	8 CONTRACT OR GRANT NUMBER(s): DACW-65-81-D-0020
9 PERFORMING ORGANIZATION NAME AND ADDRESS: Schnabel Engineering Associates, P. C. C. K. Timmons and Associates, Inc.	10 PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS:
11 CONTROLLING OFFICE NAME AND ADDRESS: U. S. Army Engineer District, Norfolk 803 Front St., Norfolk, VA 23510	12. REPORT DATE: May 1981
	13 NUMBER OF PAGES:
14 MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office):	15 SECURITY CLASS. (of this report): Unclassified
	15a. DECLASSIFICATION DOWNGRADING SCHEDULE:

Ed F. Martin
Carl A. Anderson, Jr

Report)

16 DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited

17 DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

National Dam Safety Program. Lake Front Royal Dam (Inventory Number VA 18305), Potomac River Basin, Warren County, Virginia. Phase I Inspection Report.

18 SUPPLEMENTARY NOTES

Copies are obtainable from National Technical Information Service, Springfield, Virginia 22151

19 KEY WORDS (Continue on reverse side if necessary and identify by block number)

Dams - VA
National Dam Safety Program Phase I
Dam Safety
Dam Inspection

20 ABSTRACT (Continue on reverse side if necessary and identify by block number)

(See Reverse Side)

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

20. Abstract

Pursuant to Public Law 92-367, Phase I Inspection Reports are prepared under guidance contained in the recommended guidelines for safety inspection of dams, published by the Office of Chief of Engineers, Washington, D. C. 20314. The purpose of a Phase I Inspection is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general conditions of the dam is based upon available data and visual inspection. Detailed investigation and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

Based upon the field conditions at the time of the field inspection and all available engineering data, the Phase I report addresses the hydraulic, hydrologic, geologic, geotechnic, and structural aspects of the dam. The engineering techniques employed give a reasonably accurate assessment of the conditions of the dam. It should be realized that certain engineering aspects cannot be fully analyzed during a Phase I inspection. Assessment and remedial measures in the report include the requirements of additional indepth study when necessary.

Phase I reports include project information of the dam appurtenances, all existing engineering data, operational procedures, hydraulic/hydrologic data of the watershed, dam stability, visual inspection report and an assessment including required remedial measures.

POTOMAC RIVER BASIN

NAME OF DAM: LAKE FRONT ROYAL DAM
LOCATION: WARREN COUNTY, VIRGINIA
INVENTORY NUMBER: VA. NO. 1870

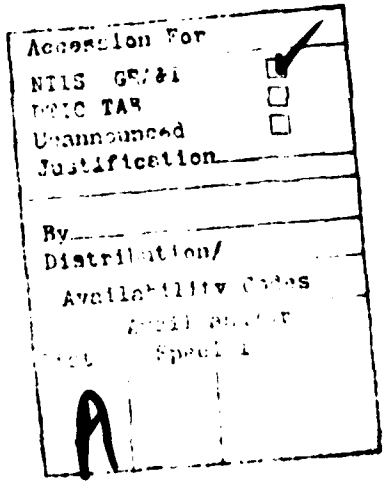
PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

PREPARED BY
NORFOLK DISTRICT CORPS OF ENGINEERS
803 FRONT STREET
NORFOLK, VIRGINIA 23510

BY

GOODKIND ENGINEERING ASSOCIATES, P.A.
W. F. TIMMONS AND ASSOCIATES, INC.

TABLE OF CONTENTS



PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D. C. 20314. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I Investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through frequent inspections can unsafe conditions be detected and only through continued care and maintenance can these conditions be prevented or corrected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the Spillway Test flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. Because of the magnitude and rarity of such a storm event, a finding that a spillway will not pass the test flood should not be interpreted as necessarily posing a highly inadequate condition. The test flood provides a measure of relative spillway capacity and serves as an aid in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

PHASE I REPORT
NATIONAL DAM SAFETY PROGRAM

BRIEF ASSESSMENT OF DAM

Name of Dam:	Lake Front Royal Dam
State:	Virginia
Location:	Warren County
USGS Quad Sheet:	Front Royal
Coordinates:	Lat 38° 52.5' Long 78° 09'
Stream:	Sloan Creek
Date of Inspection:	May 5, 1981

Lake Front Royal Dam is a zoned earthfill structure about 1600 ft long and 26 ft high. The spillway consists of a 24 inch diameter corrugated metal pipe (CMP) riser inlet and an 18 inch diameter CMP outlet which extends through the structure. Inflow to the lake is controlled by a 12 inch diameter CMP at the upper end of the impoundment. The dam is a side valley impoundment. The structure is classified small in size and is assigned a high hazard classification. The dam is located adjacent to Sloan Creek approximately 4 miles southeast of Front Royal, Virginia. The lake is used for recreational purposes, is owned by Price-Kadin Associates, Inc., and maintained by Lake Front Royal Property Owners Association, Inc.

Based on criteria established by the Department of the Army, Office of the Chief of Engineers (OCE), the appropriate Spillway Design Flood (SDF) is the ½ PMF. The spillway will pass 15 percent of the Probable Maximum Flood (PMF) or 30 percent of the SDF without overtopping the dam. During the SDF, the dam will be overtopped by a maximum of .4 ft for a period of 4 hours at a maximum velocity of 2.7 fps. Flows overtopping the dam during the SDF are not considered detrimental to the embankment with respect to erosion. The spillway is judged inadequate, but not seriously inadequate.

The visual inspection revealed no apparent problems, however, two saturated areas encountered on the downstream embankment slope above the toe are of concern. An evaluation of the stability condition could not be made since there is insufficient design and construction data for this structure.

The following remedial measures should be implemented within one year of the date of this report:

1) The Owner should engage the services of a qualified Professional Geotechnical Engineer to evaluate the two seepage areas present on the front and left downstream slope above the toe of the dam and make necessary recommendations. It is recommended that the other described saturated and iron stained areas present along the downstream toe be examined during this study to verify that no problem exists. The stability of the left upstream embankment slope should also be evaluated for the rapid drawdown condition and modified as necessary.

2) An emergency action plan should be developed.

The following routine maintenance and observation functions should be initiated:

1) The grass and weeds on the dam embankment should be cut at least once a year and preferably twice a year. Maintenance is recommended in the early summer and fall.

2) Existing trees and brush on the dam should be cut to the ground. Trees greater than 3 inches in diameter should have their stumps and root structures removed and subsequent holes backfilled and reseeded.

3) The outlet channel should be protected against erosion by lining with riprap or utilizing some other effective measure.

4) A staff gage should be installed to monitor water levels.

The Lake Front Royal Property Owners Association, Inc., is presently in the process of aquiring ownership of the dam. They have expessed a willingness to address the remedial work recommended herein upon transfer of ownership.

Prepared by:

SCHNABEL ENGINEERING ASSOCIATES, P.C./
J. K. TIMMONS & ASSOCIATES, INC.

Ray E. Martin, Ph.D., P.E.
Commonwealth of Virginia

Submitted by:

Original signed by:
Carl S. Anderson, Jr.

Carl S. Anderson, Jr., P.E.
Acting Chief, Design Branch

Approved:

Original signed by:
Ronald E. Hudson

Ronald E. Hudson
Colonel, Corps of Engineers
Commander and District Engineer

Recommended by:

Original signed by
JAMES A. WALSH

for Jack G. Starr
Chief, Engineering Division

Date: SEP 11 1981

Lake Front Royal (Looking Upstream)

Lake Front Royal (Looking Downstream

Overview Photographs

SECTION 1 - PROJECT INFORMATION

1.1 General:

1.1.1 Authority: Public Law 92-367, 8 August 1972, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a national program of safety inspection of dams throughout the United States. The Norfolk District has been assigned the responsibility of supervising the inspection of dams in the Commonwealth of Virginia.

1.1.2 Purpose of Inspection: The purpose is to conduct a Phase I inspection according to the Recommended Guidelines for Safety Inspection of Dams (see Reference 1, Appendix IV). The main responsibility is to expeditiously identify those dams which may be a potential hazard to human life or property.

1.2 Project Description:

1.2.1 Dam and Appurtenances: Lake Front Royal is a zoned earthfill structure approximately 1600 ft long and 26 ft high.* The crest of the dam is 12 ft wide, and side slopes range from approximately horizontal to 1 vertical (2H:1V) to 3.5H:1V on the downstream slope and from 2H:1V to 3H:1V on the upstream slope of the dam. The crest of the dam is at elevation 980 msl. The embankment encloses the lake on 3 sides forming a side valley impoundment. The dam includes a 1. to 15 ft wide core trench, which was excavated to 10 to 15 ft below the ground surface and extends upward to normal pool level. An internal drainage system was not provided. There is no slope protection on the upstream face of the dam.

*Height is measured from the top of the dam to the downstream toe at the centerline of the stream.

The principal spillway consists of a 24 inch diameter CMP riser inlet. The riser is connected to an 18 inch diameter CMP outlet which runs through the dam. The riser crest is at elevation 977. A 12 inch diameter opening (sealed with plate glass) in the riser at an invert elevation of 955± msl is used to drain the lake. The outlet pipe has a length of approximately 100 ft with an invert elevation at the outlet [illegible] of 954 msl (see Field Sketch 1, Appendix III).

Inflow to the lake is controlled by a 12 inch diameter CMP inlet [illegible] midway along the upper embankment (see Field Sketch 1, Appendix III). There is no control device to regulate inflow. The inlet pipe has an [illegible] elevation of 977.5 msl or approximately 0.5 ft above normal pool.

[illegible] Location: Lake Front Royal Dam is located adjacent to [illegible] 4 miles southeast of Front Royal, Virginia (see Plate 1, [illegible]).

[illegible] Classification: The dam is classified as a small size [illegible] based on its height and maximum lake storage potential as [illegible] Reference 1, Appendix I).

[illegible] Hazard Classification: The dam is located in a rural area; however, based upon the proximity of two inhabited dwellings located [illegible] mile downstream, and 5 inhabited dwellings located 2 miles± downstream, the dam is assigned a "high" hazard classification. The hazard classification used to categorize a dam is a function of location only and has nothing to do with its stability or probability of failure.

[illegible] Ownership: The dam is owned by Price-Radin Associates, Inc., and maintained by Lake Front Property Owners Association, Inc.

1.2.6 Purpose: Recreation.

1.2.7 Design and Construction History: There is no formal design for this structure. The dam was constructed under joint venture by Price-Radin Associates, Inc., and Moore, Kelly and Reddish, Inc., of Orange, Virginia. The contractor is no longer in business. The dam was completed in 1970.

1.2.8 Normal Operational Procedures: The spillway is ungated, therefore, water rising above the crest of the riser inlet is automatically discharged downstream. Normal pool is maintained at elevation 977 msl at the crest of the riser. The 12 inch diameter opening at elevation 955± is manually operated by breaking the glass seal, and is used to lower the lake elevation below normal pool for maintenance purposes. The glass seal can be broken by inserting connected small diameter pipe sections or steel rods into the outlet pipe until it reaches the glass seal at the riser. The seal is broken by pushing the pipe or rod through the glass.

The upstream inlet is ungated and receives flow from adjacent springs under normal conditions. During periods of runoff, inflow from Sloan Creek enters the lake when an overbank condition exists (2 ft± above streambed).

1.3 Pertinent Data:

1.3.1 Drainage Area: The drainage area is 0.12 square miles, direct runoff.

1.3.2 Discharge at Dam Site: Information concerning a maximum pool elevation could not be obtained.

Principal Spillway Discharge:

Pool Elevation at Crest of Dam (elev 980)	45 CFS

1.3.3 Dam and Reservoir Data: See Table 1.1, below:

Table 1.1 - DAM AND RESERVOIR DATA

	Reservoir			
	Storage			
	Elevation feet msl	Area Acres	Volume Acre Feet	Watershed Inches	Length Miles
Crest of Dam	981	7.4	84	12.8	.2
Principal Spillway Crest	[illegible]	[illegible]	[illegible]	9.4	.2
Streambed at Dam [illegible]	[illegible]	-	-	-	-

SECTION 2 - ENGINEERING DATA

2.1 Design: There was no formal design for this structure, consequently, there is no design data available.

2.2 Construction: No construction records are available. The dam was constructed by Moore, Reddish and Kelly, Inc., and completed in 1970. The contractor is no longer in business.

According to Mr. Goodwin Moore the dam has a clay core which was constructed with silty clay soils from the reservoir area. The core trench is 12 to 15 ft wide and was excavated 10 to 15 ft below the ground surface to bedrock. The core extends up to normal pool level. The rest of the embankment was constructed with sandy clay material which includes considerable gravel to boulder-size rock. All fill is reported to have been placed in 6- to 8-inch lifts and compacted with sheepsfoot rollers and [illegible]. Field density tests were not performed to determine the [illegible].

2.3 Evaluation: There is insufficient information to evaluate foundation conditions and embankment stability.

SECTION 3 - VISUAL INSPECTION

3.1 Findings: At the time of inspection, the dam was in good condition. Field observations are outlined in Appendix III.

3.1.1 General: An inspection was made on May 5, 1981. The weather was clear, the temperature was about 70°F, and the ground condition was dry. The pool and tailwater levels at the time of inspection were 976 and 954 msl, respectively. This corresponds to a below normal pool elevation and a normal tailwater elevation.

3.1.2 Dam and Spillway: The embankment is a side valley impoundment. For the purpose of this report the side paralleling Sloan Creek is termed the front of the dam, with the remaining two sides described as the left and right embankments.

The embankment slopes and crest are grassed and appear to be well maintained. Scattered trees up to 6 inches in diameter occur on the upstream slope. More trees occur on the downstream slope and there is considerable brush growing along the downstream toe. The upstream slope was measured at 3H:1V along the front of the dam and 2H:1V along the sides. The downstream slope is generally 2H:1V, but ranges from 3.5H:1V on the right side to 2H:1V near the highest point of the dam at the principal spillway (see Field Sketch 3, Appendix I).

Some scattered sloughing or erosion was encountered. A bare area exists at the northeast or right end of the dam where boats are carried across the embankment for access into the lake. Scattered deep erosion areas occur along the reservoir edge, particularly on the upstream slope, as a result of

wave action. The erosion extends into the embankment approximately 1 to 2 ft and varies from 1 to 3 ft in height. The upstream slope appears to be stable. An eroded notch approximately 10 ft long and 4 ft wide exists on the downstream slope 230 ft right of the principal spillway intake. The erosion is believed to have been caused by the creek during previous high water (see Field Sketch 3, Appendix III).

Scattered moist to saturated areas occur along the downstream toe. Sloan Creek flows along the toe, thus, it is difficult to verify whether the saturated toe condition is the result of seepage through the dam or related to flow of the creek. No flow or iron staining was observed. One saturated area of concern was encountered on the downstream slope 70 ft to the right of the principal spillway at a point estimated as being 6 ft below the crest of the dam. No flow or iron staining was observed. Considerable seepage was encountered along the left side of the dam. A saturated area ranging from 4 to 12 ft in width extends from the vicinity of the principal spillway intake to a point 103 ft± to the south. No flow or iron staining were observed. An iron stained channel flowing at 1 gpm± was encountered directly left of the intake structure. Another area of concern exists approximately 153 ft left and behind the intake structure where a saturated area extends up the slope from 18 inches± above the toe to a point 7 ft± above the toe. No flow or iron staining was observed. Finally, a large saturated and water ponded area occurs along the downstream toe from a point 153± left and behind the principal spillway intake to the abutment area. There is considerable iron staining, and flow is estimated at 1 to 3 gpm± in areas where the ground surface slopes. The saturated grassy area present along the right downstream slope is related to flows from nearby springs (see Field Sketch 3, Appendix III).

The riser, inlet and outlet pipe indicated no signs of deterioration and were functioning properly at the time of inspection. The drain opening has never been in use. The outlet channel was void of riprap and indicated some erosion.

3.1.3 Reservoir Area: The reservoir area was free of debris and the perimeter was wooded except for the embankment portion. Side valley side slopes are at approximately 3H:1V. The lake was approximately one ft below normal due to drought conditions.

3.1.4 Downstream Area: The downstream channel consists of a 6 ft wide channel located in a valley with side slopes of 2H:1V where the stream is adjacent to Route 522. There is also a 200 ft wide flood plain and 3H:1V side slopes above the flood plain. The valley is cultivated in the flood plain area and wooded above the flood plain. Approximately ¼ to ½ mile downstream there are two dwellings about 10 ft above the streambed. Approximately 2 to 2.5 miles downstream there are 5 dwellings adjacent to the stream.

3.1.5 Instrumentation: No instrumentation (monuments, observation wells, piezometers, etc.) was encountered for the structure. There is no staff gage.

3.2 Evaluation:

3.2.1 Dam and Spillways: Overall the dam was in good condition at the time of inspection. It is recommended that a routine maintenance program be initiated and documented. The embankment, including its crest and slopes should be mowed at least once a year but more preferably twice a year. The presence of trees on the embankment may promote the development of deep rooted vegetation and this type growth can encourage

piping within an embankment. All trees growing on the embankment should be cut to the ground. Trees greater than 3 inches in diameter should have their stumps and root structures removed. Subsequent holes should be filled with compacted soil and seeded. The brush present below the downstream toe along the creek channel provides erosion protection from high water. It is not necessary to remove this vegetation; however, it should not be allowed to grow on the downstream slope.

Erosion noted along the upstream slope is due to wave activity. This does not require any special attention because considerable gravel and boulders are present in the fill which act as riprap once the finer grained soils are washed away. The eroded notch in the downstream toe and the bare area caused by boat access are not hindrances to the normal functioning of the dam and no special attention is required.

The two saturated areas observed on the downstream slope (areas B and D, Field Sketch III) are of concern because they occur above the downstream toe and are believed to be related to seepage through the dam. It is recommended that a Professional Engineer with expertise in Geotechnical Engineering be contacted to evaluate these two areas and make recommendations for any required remedial measures. The other saturated and/or iron stained areas (C, E and F, Appendix III) do not present a hindrance to the normal functioning of the dam, however, it is recommended that they also be reviewed, particularly the iron stained areas (E and F), by the Geotechnical Engineer to verify that no problem exists. The saturated grassy area along the right downstream slope is the result of ponded spring water and does not require any attention.

The outlet and inlet pipes and intake structure are in good structural condition. Riprap should be placed in the outlet discharge channel to reduce erosion during future flooding. A staff gage should be installed to monitor water levels.

3.2.2 Downstream Area: A breach in the Lake Front Royal Dam during extreme flooding would create a hazard to the downstream dwellings.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 Procedures: The normal storage pool is elevation 977 msl at the crest of the spillway inlet. The lake provides recreation. Water automatically passes through the spillway as the water level in the reservoir rises above the spillway crest. Water will also pass automatically into the lake through the inlet pipe when the stream level reaches the inlet pipe elevation. A 12 inch opening in the 24 inch diameter riser structure is provided to drawdown the reservoir below normal pool.

4.2 Maintenance of Dam and Appurtenances: Maintenance is the responsibility of the owner. Maintenance consists of inspection, debris removal, mowing of vegetative cover and repair. Maintenance is not routinely performed.

4.3 Warning System: At the present time, there is no warning system or evacuation plan for the dam.

4.4 Evaluation: The dam and appurtenances are in good operating condition, and maintenance of the dam appeared to be adequate. Documentation and establishment of a routine maintenance program should be developed for this structure. An emergency operation and warning plan should be developed. It is recommended that a formal emergency procedure be prepared and furnished to all operating personnel. This should include:

a. How to operate the dam during an emergency.

b. Who to notify, including public officials, in case evacuation from the downstream area is necessary.

SECTION 5 - HYDRAULICS/HYDROLOGIC DATA

5.1 Design: There was no formal design for Lake Front Royal Dam and there is no hydrologic or hydraulic data available.

5.2 Hydrologic Records: There are no records available.

5.3 Flood Experience: Information on flood experience was not available.

5.4 Flood Potentials: In accordance with the established guidelines, the Spillway Design Flood is based on the estimated "Probable Maximum Flood" for the region (flood discharges that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region), or fractions thereof. The Probable Maximum Flood (PMF) and ½ PMF and 100 year flood hydrographs were developed by the HEC-1 method (Reference 4, Appendix IV). Precipitation amounts for the flood hydrograph of the PMF and 100 year flood were taken from U. S. Weather Bureau Information (References 5 and 6, Appendix IV). Appropriate adjustments for basin size and shape were accounted for. These hydrographs were routed through the reservoir to determine maximum pool elevations.

5.5 Reservoir Regulations: For routing purposes, the pool at the beginning of flood was assumed to be at elevation 977 msl. Reservoir stage-storage data and stage-discharge data were computed from field sketches and available topographic data. Floods were routed through the reservoir using the spillway discharge up to a pool storage elevation of

980 msl. Inflow to the lake was restricted to direct runoff and the inlet pipe capacity. Pool elevations above 980 msl were routed over the non-overflow section of the dam.

5.6 Overtopping Potential: The predicted rise of the reservoir pool and other pertinent data were determined by routing the flood hydrographs through the reservoir as previously described. The results for the flood conditions (100 year flood, ½ PMF and PMF) are shown in the following Table 5.1:

TABLE 5.1 - RESERVOIR PERFORMANCE

		Hydrograph		
	Normal Flow	100 Year Flood	½ PMF	PMF
Peak Flow, CFS				
Inflow	-	291	711	1421
Outflow	-	171	698	1368
Maximum Pool Elevation Ft, msl	980	980.1	980.4	980.6
Non-Overflow Section (Elev 980 msl				
Depth of Flow, Ft	-	.1	.4	.6
Duration, Hour	-	1.5	4	9
Velocity, fps *	-	1.4	2.7	3.3
Tailwater Elevation Ft, msl	954	960.1	963.9	968.2

* Critical velocity

5.7 Reservoir Emptying Potential: A 12 inch diameter gate at elevation 955 msl is capable of draining the reservoir through the outlet pipe. Assuming that the lake is at normal pool elevation (977 msl) and there is .2 cfs inflow, it would take approximately 2.5 days to lower the reservoir to elevation 955 msl. This is equivalent to an approximate drawdown rate of 8.8 ft/day based on the hydraulic height measured from normal pool to the invert of the drawdown pipe divided by the time to dewater the reservoir.

5.8 Evaluation: The U.S Army, Corps of Engineers' guidelines indicate the appropriate Spillway Design Flood (SDF) for a small size, high hazard dam is the ½ PMF to PMF. Because of the risk involved, the ½ PMF has been selected as the SDF. The spillway will pass 75 percent of the PMF without overtopping the crest of the dam (50 percent of the SDF).

During the SDF, the dam will be overtopped by a maximum of 0.4 ft for a period of 4 hours at a maximum velocity of 2.7 fps.

Hydrologic data used in the evaluation pertains to present day conditions with no consideration given to future development.

SECTION 6 - DAM STABILITY

6.1 Foundation and Abutments: The dam is located along the western edge of the Blue Ridge physiographic province of Virginia. The impoundment and structure are underlain by the Catoctin Formation of late Precambrian age. The Catoctin consists of assorted mixtures of greenstone, phyllite, argillite and metamorphosed arkose and sandstone. No faults have been mapped in the immediate area.

The potential for seepage within the foundation was apparently recognized by the contractor, since it was reported that a cutoff trench was constructed. According to Mr. Moore, a 12 to 15 ft wide cutoff was undercut [illegible] to bedrock at depths ranging from 10 to 15 ft below the ground surface.

Radial consolidation of underlying soils would be expected during [illegible] fill materials. The underlying soils probably had essentially [illegible] after the upstream shell was placed after completion of [illegible]. Because of the relatively shallow depth of this dam and the [illegible] of the relatively slow channel, a stable foundation is [illegible].

6.2 Embankment:

6.2.1 Materials: The dam was designed as a zoned embankment. The [illegible] materials (CL) encountered on site were placed in the core trench and central portion of the dam. The remainder of the embankment was constructed with clayey sand (SC) materials which include considerable gravel and boulders. The fill was placed in 12 inch layers and compacted with sheepfoot rollers and pans. No field density tests were taken to determine the percent compaction.

[illegible] Drainage and Seepage: There is no internal drainage system for this structure. Saturated ground conditions present along the downstream toe are believed to be related to Sloan Creek. Saturated and iron stained areas present on the left side of the embankment are believed to be related to seepage through the dam. Two saturated areas (B and D) occur above the embankment toe and are of concern because they also are believed to be the result of seepage through the dam. The saturated grassy area along the right downstream edge is related to flows from nearby springs.

[illegible] Stability: A stability analysis was not performed for this structure. The dam is 16 ft high and has a crest width of 12 ft. Side slopes are approximately 3H:1V along the front side and 2H:1V on the sides of the upstream edge. The downstream slope ranges from 3.5H:1V on the right side to 2H:1V on the front and left sides (see Field Sketch 3, Appendix III).

[illegible] is an earth embankment and was reported to [illegible] material and SC material with gravel and [illegible]. Since the actual width of the core is not [illegible] shell described by the [illegible], the [illegible] is assessed assuming a [illegible] to rapid drawdown because the [illegible] drawdown rate of 5.6 ft per day exceeds the critical [illegible]. According to guidelines presented in [illegible], U.S. Department of the Interior, Bureau of Reclamation [illegible], subjected to a drawdown [illegible] of SC materials, the recommended slopes are [illegible] upstream and 3H:1V downstream. The recommended crest width is 15 ft. [illegible] material conditions, the downstream slopes and front portion of the upstream slope are considered acceptable. The left and right upstream

slopes are considered too steep for the rapid drawdown condition and the embankment crest is too narrow.

6.2.4 Seismic Stability: The dam is located in Seismic Zone 2. Therefore, according to the Recommended Guidelines for Safety Inspection of Dams, the dam is considered to have no hazard from earthquake provided static stability conditions are satisfactory and adequate freeboard exists.

6.3 Evaluation: An accurate check on the stability of this structure cannot be made since there was no stability analysis and laboratory test data available. Foundation conditions are not known, but a stable foundation is assumed based upon the visual inspection and available geologic maps. The downstream embankment slopes and the crest [illegible] the requirements recommended by the Corps of Engineers for high hazard dams. [illegible] is too steep, but the [illegible] also too steep, however, [illegible] recommended that a reconnaissance be made to evaluate the [illegible] of the left upstream [illegible]. The embankment crest [illegible] but this deficiency is not considered a problem. Overtopping is not considered detrimental to the dam with respect to erosion because of the shallow depth and short duration of flood. Also the velocity is considerably less than 6 fps, the effective velocity for a vegetated earth embankment. Since no undue settlement, cracking, or seepage was noted at the time of inspection,

It appears that the embankment is adequate for control storage at elevation 977 msl.

The two saturated areas observed on the downstream slope (areas B and D, Field Sketch 3, Appendix III) are of concern because they occur above the downstream toe and are believed to be related to seepage through the dam. It is recommended that a Professional Engineer with an expertise in Geotechnical Engineering be contacted to evaluate these two areas and make recommendations for any required remedial measures. Although other areas identified from stained and saturated areas are considered less serious, it is recommended they also be examined by the Geotechnical Engineer to verify that a problem does not exist.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 Dam Assessment: There is insufficient information for evaluating foundation conditions and embankment stability. The visual inspection revealed no findings that proved the dam to be unsound, however, two saturated areas on the downstream slope above the toe are of concern. Also, the left embankment upstream slope is considered inadequate and a stability check is required. A routine maintenance program does not exist. Also, there is no emergency operation and warning plan. Overall, the dam was in good at the time of inspection. The U. S. Army, Corps of Engineers' guidelines indicate the appropriate Spillway Design Flood (SDF) for this dam is the ½ PMF. The spillway will pass 15 percent of the PMF (30 percent of the SDF) without overtopping the crest of the dam. Flows overtopping the dam at a maximum velocity of 2.7 fps during the SDF are not considered detrimental to the embankment with respect to erosion. The spillway is, therefore, inadequate, but not seriously inadequate.

7.2 Recommended Remedial Measures: The following remedial measures should be implemented within one year of the date of this report.

7.2.1 The owner should engage the services of a qualified Professional Geotechnical Engineer to evaluate the two seepage areas present on the downstream slope above the toe of the dam and make necessary recommendations. It is recommended that other described saturated and iron stained areas be examined to verify that no problem exists. Furthermore, the stability of the left upstream embankment slope should also be evaluated and modified as necessary.

7.2.2 An emergency operation and warning plan should be developed to warn downstream dwellings of any dangers which may be imminent. This

plan should include:

1) How to operate the dam during an emergency.

2) Who to notify, including public officials, in case evacuation from the downstream area is necessary.

7.2 Required Maintenance and Observation: It is recommended that a regular maintenance operation program be established and documented for future reference. Also, the inspection revealed the following maintenance items that should be [illegible] by the owner [illegible] regular maintenance [illegible]:

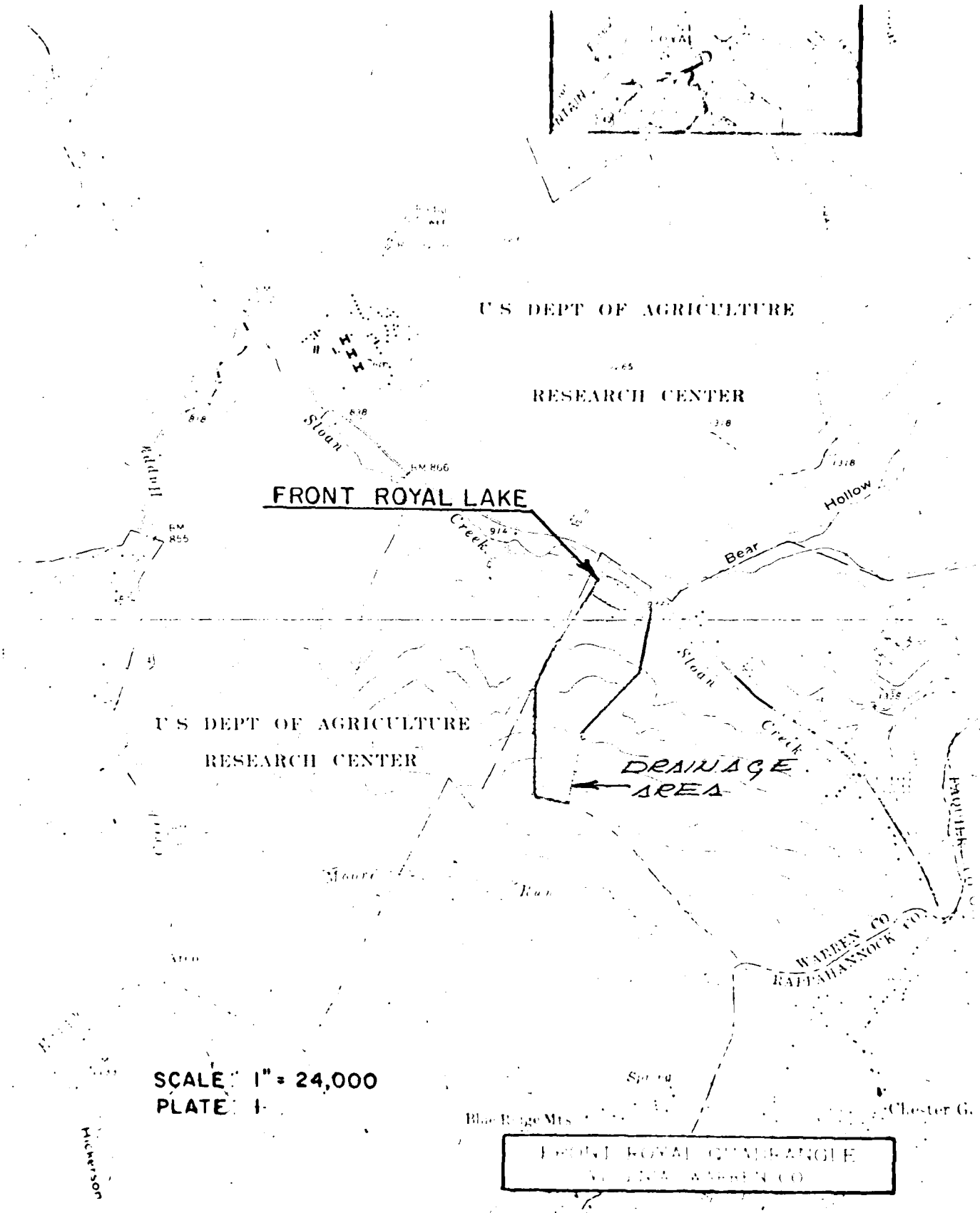
7.2.1 The grass and weeds on the dam embankment should be cut at least [illegible] and preferably twice a year. Maintenance is recommended [illegible] and fall.

[illegible] trees and brush on the dam should be cut to the ground. [illegible] large and root [illegible] and seeded.

[illegible] should be protected [illegible] effective measure. [illegible] water levels.

APPENDIX I

MAPS AND DRAWINGS


U S DEPT OF AGRICULTURE
RESEARCH CENTER
FRONT ROYAL LAKE
Sloan
Creek
Hopper
Hollow
Bear
SR 855
SR 866
DRAINAGE AREA
U S DEPT OF AGRICULTURE
RESEARCH CENTER
Moore
Run
WARREN CO.
RAPPAHANNOCK CO.
Blue Ridge Mts
Clester G.
FRONT ROYAL QUADRANGLE
SCALE 1" = 24,000
PLATE 1

Photograoh No. 1 - Upstream Slope and Inlet Pipe

Photograph No. 2 - Downstream Slope

Photograph No. 3 - Intake Structure

Photograph No. 4 - [illegible]

Photograph No. 5 - Stream (Arrow) at Toe of Embankment

Photograph No. 6 - Downstream Channel

Check List
Visual Inspection
Phase I

Name Dam Front Royal Lake County Warren State Virginia Coordinates

Date(s) Inspection May 5, 1981 Weather Sunny-Clear Temperature 75°F

Pool Elevation at Time of Inspection 976 msl Tailwater at Time of Inspection

Inspection Personnel:

Schnabel Engineering Associates, P.C.
Gilbert T. Sense
Stephen G. Werner
Raymond A. DeStephen, P.E.*

J. K. Timmons & Associates
Robert G. Roop, P.E.
Steve Gaul

Gilbert T. Sense, Recorder

* Not present during the inspection, but visited the dam on June 1, 1981.

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS	The slopes, crest and abutments of the dam were inspected and no cracks were noted. Ground conditions were dry at the time of the inspection.	–
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	No unusual movements were noted on the dam or beyond the downstream toe.	–
SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES	Sloughing at NE corner due to boat access into the lake. No real problem, just a bare area. Some erosion of the downstream toe along the [illegible] side of the dam approximately 230 ft from the riser pipe. Scattered steeply eroded areas along upstream slope 1 to 3 ft above pool level and are 1 to 2 ft into the embankment are the result of wave action. [illegible] slopes are 1H:1V.	See [illegible]
VERTICAL AND HORIZONTAL ALIGNMENT OF THE CREST	The vertical and horizontal alignment of the dam appears to be good.	–
RIPRAP FAILURES	There was no riprap placed during construction. The embankment fill includes considerable gravel and boulders which appear to act as riprap along the upstream slope at pool level since fines have been washed from the fill.	–

ANY [illegible]	[illegible]
DRAINS	None
MATERIALS	According to Mr. [illegible] [illegible] to the [illegible] 15 ft wide. [illegible] constructed [illegible] consists of [illegible] clay material [illegible] Considerable [illegible] and boulders [illegible] along the [illegible] Fines observed include SC, CL and SM materials.
VEGETATION	The embankment is grassed and appears to be well maintained [illegible] presence of [illegible] trees up to [illegible] inches in diameter on the upstream [illegible] [illegible] the downstream slope and there is considerable brush [illegible] along the downstream toe.

			REMARKS AND RECOMMENDATIONS
			Principal spillway in good condition
			Nursery area
			-
			-
			-

VISUAL EXAMINATION	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
[illegible]	[illegible] Spillway	-
[illegible]	[illegible]	-
[illegible]	None	-
BRIDGE AND PIERS	None	-
MISCELLANEOUS	-	-

INSTRUMENTATION

VISUAL EXAMINATION OF	OBSERVATIONS
MONUMENTATION/SURVEYS	None observed
OBSERVATION WELLS	None observed
WEIRS	None observed
PIEZOMETERS	None observed
STAFF GAGES	None observed
OTHER	-

VISUAL EXAMINATION	OBSERVATIONS
	Steep embankment [illegible]. The water [illegible]. Minor erosion exists along [illegible] wave action. The area around the reservoir [illegible] wooded to open and rolling [illegible]. [illegible] areas occur along the west [illegible]. A creek or stream bounds the northern [illegible] by the highway. The reservoir area was [illegible].
SLOPES	
	None. The water is clear. Mr. Moore reported that the lake was about 15 ft deep
SEDIMENTATION	

VISUAL EXAMINATION OF

CONDITION (OBSTRUCTIONS, DEBRIS, ETC.)	Vegetated with [illegible]. The flood plain is [illegible] above the flood [illegible].
SLOPES	Flood plain and [illegible] and has 3H:1V [illegible] and has 3H:1V [illegible] channel [illegible] approximately 3H:1V.
APPROXIMATE NO. OF HOMES AND POPULATION	Two homes occur [illegible] approximately [illegible] by normal stream [illegible] buildings occur [illegible].

CHECK LIST

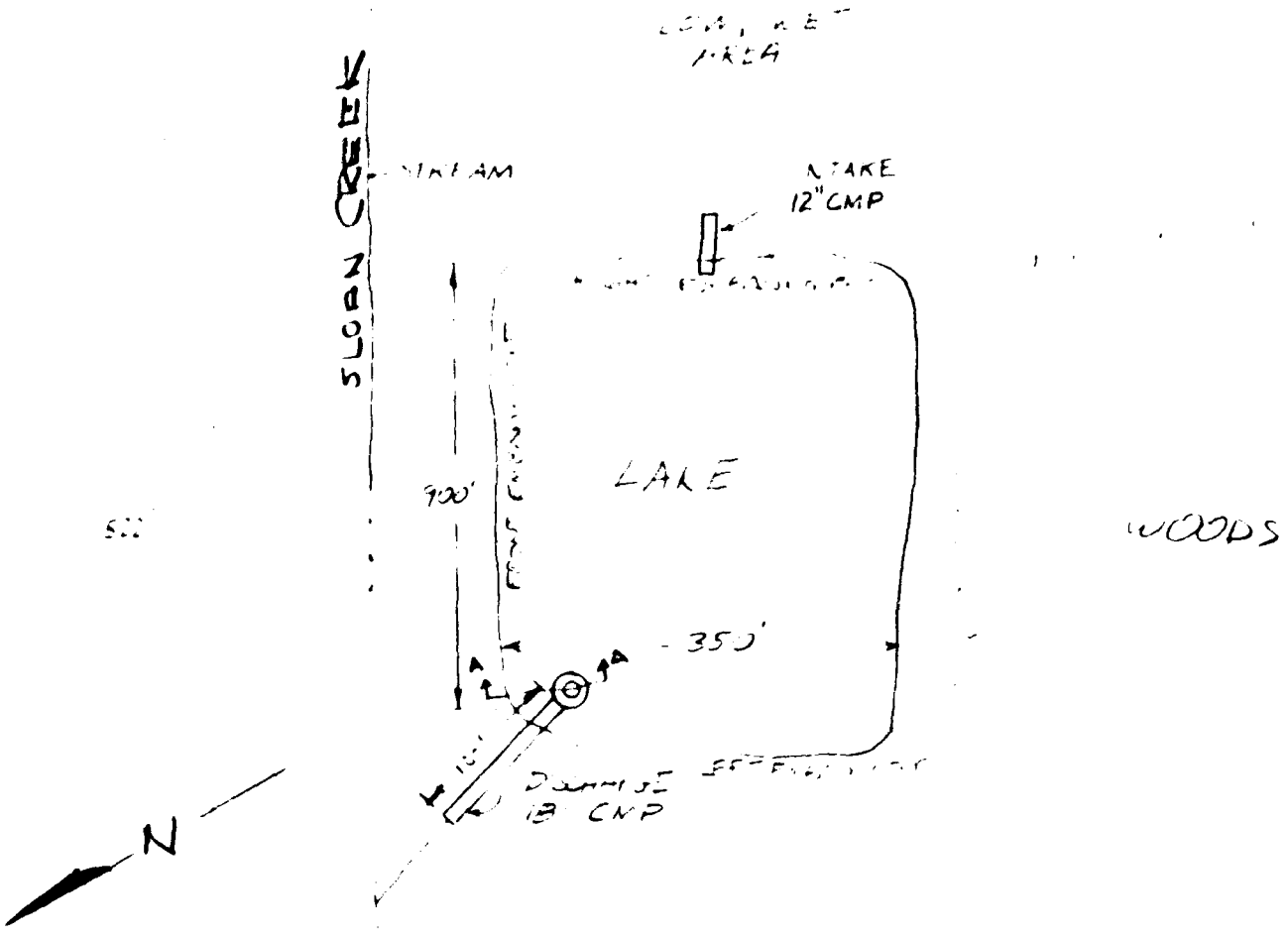
ENGINEERING DATA

DESIGN, CONSTRUCTION, [illegible]

ITEM	REMARKS
[illegible] VICINITY MAP	Front Royal, Virginia [illegible] 7. minute topographic map
[illegible]/CONSTRUCTION HISTORY	The dam was designed and [illegible] of Orange Virginia, and [illegible] 10-15 ft deep, 12 to 15 ft wide [illegible] The remainder of the dam was [illegible] silty clay with gravel and [illegible] sheepsfoot roller but no density [illegible]
[illegible] OF DAM	None available
TYPICAL SECTIONS OF DAM	None available
OUTLETS - PLAN DETAILS CONSTRAINTS DISCHARGE RATINGS	None available
SPILLWAY- PLAN SECTION DETAILS	None available
OPERATING EQUIPMENT - PLAN DETAILS	None available

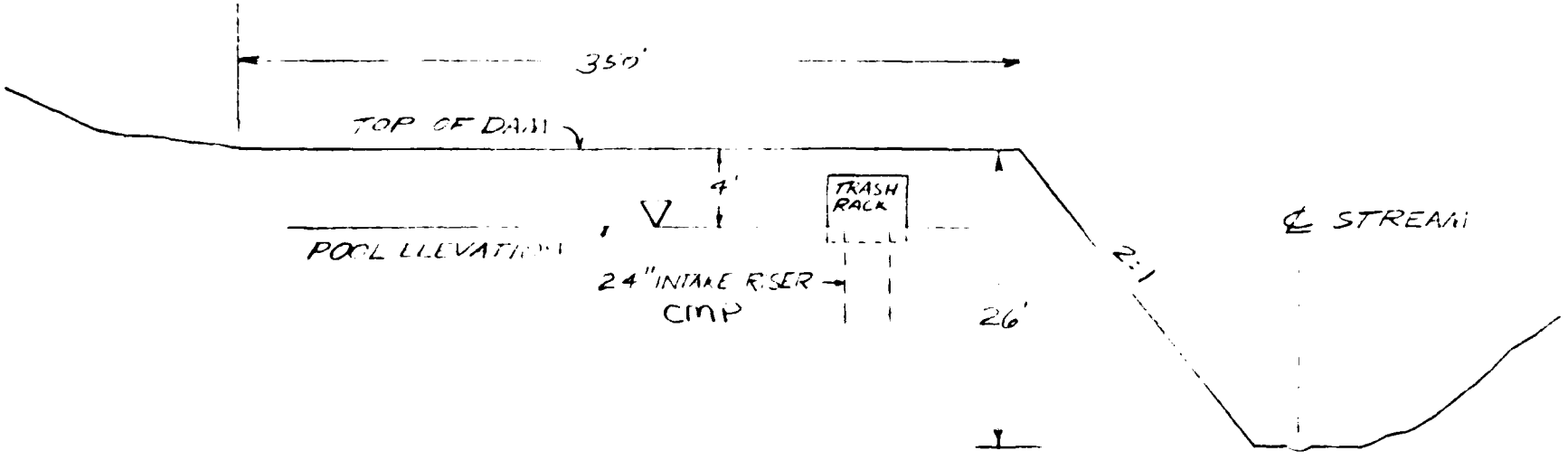
ITEM	REMARKS
MONITORING SYSTEMS	None observed
RAINFALL/RESERVOIR HIGHPOOL RECORDS	None
GEOLOGY REPORTS	Geology of the Front Royal Quadrangle, Virginia by E. K. Rader & T. H. Biggs, Virginia Department of Mineral Resources, Reports of Investigations #[illegible].
BORROW SOURCES	Reservoir
MATERIALS INVESTIGATIONS BORING RECORDS LABORATORY-FIELD TEST DATA	None
HYDROLOGIC/HYDRAULIC DATA	None

ITEM		REMARKS
DESIGN REPORTS	None	-
DESIGN COMPUTATIONS HYDROLOGY & HYDRAULICS DAM STABILITY SEEPAGE STUDIES	None	-
POST CONSTRUCTION ENGINEERING STUDIES RECORDS, SURVEYS	None	-
MODIFICATIONS	None	-
PRIOR ACCIDENTS OR FAILURE OF DAM DESCRIPTION REPORTS	None	-
MAINTENANCE OPERATION RECORDS	None	-

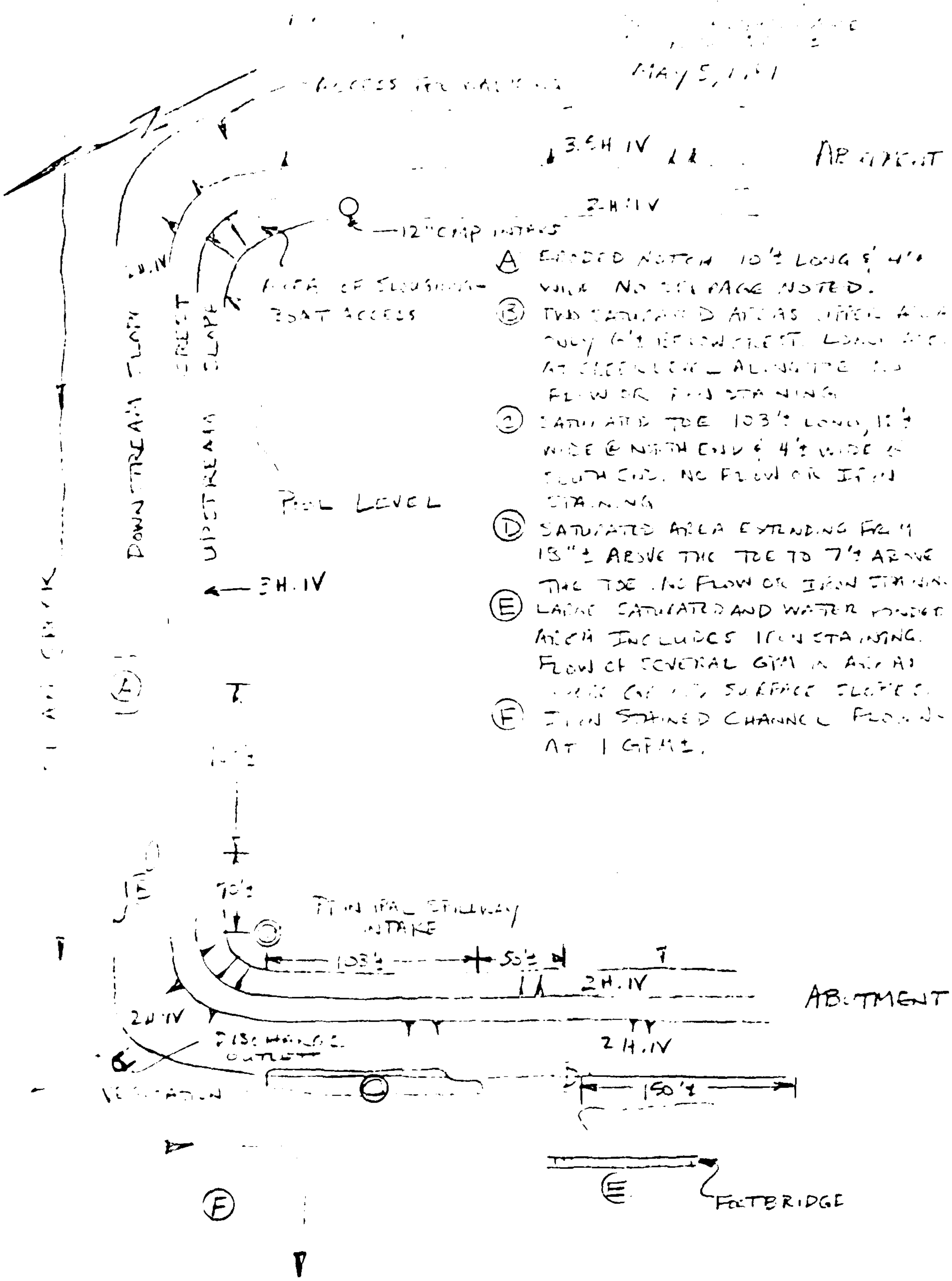


PLAN
FRONT ROYAL LAKE
FIELD SKETCH 1

5 MAY 1981



PROFILE (SECT A-A)
FRONT ROYAL LAKE
FIELD SKETCH 2
5 MAY 1981



A ERODED NOTCH 10'± LONG & 4'± WIDE. NO SEEPAGE NOTED.

B TWO SATURATED AREAS. UPPER AREA ONLY 6'± BELOW CREST. LOWER AREA AT [illegible] ALONG THE [illegible] FLOW OR IRON STAINING.

C SATURATED TOE 103'± LONG, 15'± WIDE @ NORTH END & 4'± WIDE @ SOUTH END. NO FLOW OR IRON STAINING.

D SATURATED AREA EXTENDING FROM 15"± ABOVE THE TOE TO 7'± ABOVE THE TOE. NO FLOW OR IRON STAINING.

E LARGE SATURATED AND WATER PONDED AREA INCLUDES IRON STAINING. FLOW OF SEVERAL GPM IN AREA AT [illegible] SURFACE SLOPES.

F IRON STAINED CHANNEL FLOWING AT 1 GPM±.

APPENDIX IV - REFERENCES

1. Recommended Guidelines for Safety Inspection of Dams, Department of Army, Office of the Chief of Engineers, 46 pp.
2. Design of Small Dams, U. S. Department of Interior, Bureau of Reclamation, 1974, 816 pp.
3. Geology of the Front Royal Quadrangle Virginia, by E. K. Rader and T. H. Biggs, Virginia Division of Mineral Resources, Reports of Investigation No. 40, 91 pp.
4. HEC - 1 Dam Break Version, Flood Hydrograph Package, Users Manual For Dam Safety Investigations, the Hydrologic Engineering Center, U. S. Army Corps of Engineers, September, 1978.
5. Hydrometerologic Report No. 33, U. S. Department of Commerce, Weather Bureau, U. S. Department of Army, Corps of Engineers, Washington, D. C., April, 1956.
6. Technical Paper No. 40, U. S. Department of Commerce, Weather Bureau, Washington, D. C., May, 1961.

END

DATE
FILMED

11-81

DTIC